

1 What is claimed is:

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3 1. A method of vacating a portion of a photoceram, the method  
4 comprising,

5 generating a laser beam at a predetermined wavelength within a  
6 weak absorption region of the photoceram,

7 focusing the laser beam into a beam waist at a focal depth into  
8 the photoceram,

9 illuminating the photoceram by the laser beam to expose a focal  
10 volume of the photoceram at a focal depth where the laser beam  
11 converts the photoceram into an amorphous exposed material in the  
12 focal volume,

13 heating the amorphous exposed material for forming crystallized  
14 material from the amorphous exposed material in the focal volume,  
15 and

16 dissolving the crystallized material in an acid for evacuating  
17 crystallized material from the focal volume and creating a focal  
18 volume vacancy defining the portion.

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21 2. The method of claim 1 wherein,

22 the portion serves to suspend another portion of the  
23 photoceram.

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26 3. The method of claim 1 wherein,

27 the portion serves to undercut another portion of the  
28 photoceram.

1 4. A method of forming a three dimensional embedded structure in a  
2 photoceram, the method comprising,  
3 generating a laser beam at a predetermined wavelength within a  
4 weak absorption region of the photoceram,  
5 focusing the laser beam into a beam waist at a focal depth into  
6 the photoceram,  
7 illuminating the photoceram by the laser beam to expose a focal  
8 volume of the photoceram at a focal depth where the laser beam  
9 converts the photoceram into an amorphous exposed material in the  
10 focal volume,  
11 heating the amorphous exposed material for forming crystallized  
12 material from the amorphous exposed material in the focal volume,  
13 and  
14 dissolving the crystallized material in an acid for evacuating  
15 crystallized material from the focal volume and creating a focal  
16 volume vacancy defining the three dimensional embedded structure.

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19 5. The method of claim 4 wherein,  
20 the photoceram is Foturan, and  
21 the predetermined wavelength is greater than 350nm.  
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26 6. The method of claim 4 wherein,  
27 the predetermined wavelength is an ultraviolet wavelength.

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1 7. The method of claim 4 wherein the illuminating step comprises  
2 the steps of,

3 exposing the photoceram at the predetermined wavelength for a  
4 predetermined number of pulses to provide a critical dose at the  
5 focal depth for creating a pixelized volume of amorphous exposed  
6 material,

7 moving the photoceram a predetermined step distance relative  
8 to the laser beam, and

9 repeating the exposing and moving step a plurality of times  
10 for creating a respective plurality of pixelized volumes forming  
11 the focal volume.

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13 8. The method of claim 7 wherein,

14 the predetermined number of pulses is between 100 and 10000  
15 for delivering the critical dose for converting the photoceram into  
16 the amorphous exposed material.

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18 9. The method of claim 4 wherein the dissolving steps 4 further  
19 comprising the steps of,

20 forming a top via in the photoceram for communicating the acid  
21 into the focal volume for dissolving the crystalline material in  
22 the focal volume,

23 dissolving the crystalline material in the focal volume with  
24 the acid communicated into the focal volume through the top via,

25 forming a bottom via in the photoceram for vacating dissolved  
26 crystalline material out of the focal volume, and

27 vacating the dissolved crystalline material through the bottom  
28 via.

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2 10. The method of claim 9 wherein the forming steps for forming  
3 the top and bottom via comprise the steps of,  
4 exposing the photoceram in a top region for creating a top via  
5 volume of amorphous expose material for defining the top via,  
6 exposing the photoceram in a bottom region for creating a  
7 bottom via volume of amorphous expose material for defining the  
8 bottom via, the baking step serving to bake the amorphous exposed  
9 material in the top and bottom via volumes into crystallized  
10 material, the dissolving step serving to dissolve the crystallized  
11 material out of the top and bottom volumes for forming the top via  
12 and bottom vias.  
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1 11. The method of claim 4 wherein,

2 the illumination step exposes the focal volume during an  
3 exposure time at an intensity level,

4 the intensity level and the exposure time provide an exposure  
5 dose above a minimum critical dose necessary for converting the  
6 photoceram into the amorphous exposed material, and

7 the minimum critical dose is a nonlinear function of the  
8 intensity level.

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12 12. The method of claim 4 wherein,

13 the laser is a pulsed laser,

14 the laser beam is a pulsed laser beam having a predetermined  
15 number of pulses,

16 the illumination step exposes the focal volume for the  
17 predetermined number of pulses having a per pulse fluence level  
18 over a predetermined pulse width time,

19 the per pulse fluence level and the predetermined number of  
20 pulses provide an exposure dose above a minimum critical dose  
21 necessary for converting the photoceram into the amorphous exposed  
22 material, and

23 the minimum critical dose is a nonlinear function of the per  
24 pulse fluence level.

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1 13. A method of forming a three dimensional embedded structure in a  
2 photoceram, the method comprising,

3 generating a pulsed laser beam at a UV wavelength within a weak  
4 absorption band of the photoceram,

5 focusing the laser beam into a beam waist at a focal depth into  
6 the photoceram,

7 exposing the photoceram at the UV wavelength a predetermined  
8 number of pulses at focal depth for creating a pixelized volume of  
9 amorphous exposed material,

10 moving the photoceram a predetermined step distance, and

11 repeating the exposing and moving step a plurality of times  
12 for creating a respective plurality of pixelized volume forming a  
13 focal volume,

14 heating the photoceram to heat the amorphous exposed material  
15 in the focal volume to bake the amorphous material into a  
16 crystallized material, and

17 dissolving the crystallized material in an acid for evacuating  
18 the crystallized material from the focal volume creating a focal  
19 volume vacancy defining the three dimensional embedded structure.

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21 14. The method of claim 13 wherein,

22 the photoceram is Foturan,

23 the ultraviolet wavelength is 355nm, and

24 the number of pulses is between 100 and 10000.

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26 15. The method of claim 13 wherein,

27 all the steps are repeated for forming a plurality of  
28 embedded structures.

1 16. The method of claim 13 wherein the embedded structure is an  
2 undercut structure.

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4 17. The method of claim 13 further comprising the step of,  
5 agitating the acid for transporting the acid through the top  
6 via into the focal volume.

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8 18. The method of claim 13 further comprising the step of,  
9 pressurizing the acid for transporting the acid through the  
10 top via into the focal volume.

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12 19. The method of claim 13 wherein the illumination laser beam has  
13 a Gaussian profile and is focused at the focal depth in the  
14 photoceram.

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17 20. The method of claim 13 wherein,  
18 the UV wavelength is at an edge between the weak absorption  
19 region and the strong absorption region of the photoceram,  
20 the illumination step exposes the focal volume for the  
21 predetermined number of pulses having a per pulse fluence level  
22 over a predetermined pulse width time,  
23 the per pulse fluence level and the predetermined number of  
24 pulses provide an exposure dose above a minimum critical dose  
25 necessary for converting the photoceram into the amorphous exposed  
26 material, and  
27 the minimum critical dose is a nonlinear function of the per  
28 pulse fluence level.